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(54) **BYPASS CIRCUIT FOR USE IN DC BRUSH MOTOR CONTROL**

BYPASS-SCHALTUNG IM EINSATZ MIT EINER GLEICHSTROMMOTOR-REGELUNG

CIRCUIT DE DERIVATION DESTINE A ETRE UTILISE DANS UNE COMMANDE DE MOTEUR A
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EP-A- 0 895 346 **US-A- 6 078 204**

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EP 1 340 313 B1

Description

[0001] The present invention relates to a circuit for bypassing the Zener diodes connected across a DC brush motor to control the speed of the motor when the motor moves in reverse under the force of a bias device such as a spring.

[0002] In a co-pending patent application of Christopher M. Lange entitled "Drive Circuit and Method for an Electric Actuator with Spring Return" Serial No. 08/904,005, filed July 13, 1997, and assigned to the assignee of the present invention, an actuator system is shown in which an output shaft is positioned by a spring in a first position and upon command, is driven through a gear train to a second position by an electric motor. The circuit includes an input circuit for providing a current large enough to rotate the shaft against the force of the spring. A rotation sensor produces a signal when the motor and shaft are stalled at the second position and a modulation circuit receiving the signal from the rotation sensor operates to reduce the current to the motor so as to hold the stalled shaft and motor at the second position with a minimum of energy usage. When the current to the motor is removed, the spring forces the motor in reverse and the shaft returns to the first position. A Zener diode and a conventional diode are connected in series, between the power terminals of the motor to provide a current circulation path which regulates the voltage induced across the windings of the motor and enhances the braking effect provided by the motor in its unenergized state when it is rotating in reverse under the force of the bias. Unfortunately, during powered operation, when the motor is driving the shaft toward the second position, the current passes through the Zener diode causing extra power consumption and reducing the efficiency rate.

[0003] EP-A-0895346 discloses an apparatus for use with a motor which energises the motor with a voltage source and has a voltage control device in its fly back path. US-A-6078204 discloses a bypass circuit for an FET.

[0004] The present invention overcomes the problem of wasted energy passing through the Zener diode(s) during forward operation by providing a bypass circuit that is activated to bypass the Zener diode(s) during forward operation.

[0005] According to the present invention there is provided apparatus for use with a motor which is energized by a voltage source to drive in a first direction and which returns in a opposite direction under the force of a bias when the voltage source is removed, the motor having a voltage control device in the flyback path to limit the voltage induced during the return, the apparatus characterised by comprising:

a voltage controlled switch connected across the voltage control device to short circuit the voltage device when activated; and

a sensor connected to activate the voltage-controlled switch when the motor is energized to drive in the first direction.

[0006] A corresponding method is also provided.

[0007] Figure 1 is a schematic diagram of the preferred embodiment of the present invention.

[0008] In Figure 1, the circuit labeled "Zener Diode Bypass", 10, is shown connected by a line, 12 to a source of DC voltage, 14, identified as VM. A motor 20, is shown, having a first input terminal, 21, connected to line, 12, and a second input terminal, 22, connected through a switch, 24, to signal ground. Motor, 20, operates through a gear train, 26, to drive a shaft, 28, against the bias of a spring, 30, from a first, or rest position, to a second, or stalled position. For example, shaft, 28, may be connected to the damper valve of a heating or cooling system (not shown) where the first, or rest position, is fully closed and the second, or stalled position, is fully open. The speed of motor, 20, while it is driving from the first position to the second position, is controlled by switch, 24, which may be a FET which opens and closes very rapidly in a manner described and claimed in the above-mentioned co-pending application Serial Number 08/904,005. At the stalled position, the motor, 20, has enough power to hold the valve at the fully open position. When the motor, 20, is turned off, as by removal of the voltage VM. the spring, 30. will rotate shaft, 28, in the opposite direction driving motor, 20, in reverse, back to the closed position.

[0009] Connected across motor 20, from junction point 21 to junction point 22, are two series connected Zener diodes, 32 and 34, connected, at a junction point 35, to a conventional diode, 36, in cathode-to-cathode relationship. While two Zener diodes, 32 and 34, have been shown, the number may vary depending on power dissipation needed.

[0010] Since the speed of return is proportional to the voltage across Zener diodes, 32 and 34, their value determines the spring return speed of the actuator, and, accordingly, a major purpose of Zener diodes, 32 and 34, is to regulate the voltage induced across the windings of motor, 20, to control the speed of return of motor, 20, to the first position and to enhance the braking effect provided by motor, 20, when power is removed. However, because they are in the "flyback" current path, Zener diodes, 32 and 34, waste energy during the forward drive mode of the actuator. Accordingly, it is desirable to bypass Zener diodes, 32 and 34, when the motor 20 is driving forward to the second position.

[0011] This has been accomplished in a previously sold damper circuit, (identified by Honeywell as the ML8105 Fast Acting Two Position Actuator), using a current controlled bypass transistor connected across the Zener diodes which is actuated to an "on" condition, to short circuit the Zener diodes, when current flows between the emitter and collector of the transistor. Since current flow from emitter to collector occurs when the transistor is "on" and when flyback current is flowing

through the motor (i.e., when VM is applied and when the rapid acting switch, or FET, is open), the Zener diodes are short circuited, as desired, when the motor is forward driving. Unfortunately, when the rapid acting switch, or FET, is closed, as happens very rapidly to control the motor current, the transistor turns "off" and the Zener diodes are not short circuited. When the rapid acting switch, or FET, opens again, the transistor is "off" and is forced to turn back "on" to allow the motor flyback current to pass through it from emitter to collector. Even though this transistor turns back "on" very rapidly, significant undesirable energy is dissipated because the motor flyback current must pass through the Zener diodes during the short period of time while the transistor is turning back "on." The present invention overcomes this problem by using a Zener Diode Bypass circuit in which the bypass transistor is voltage controlled, as will be described.

[0012] Connected across Zener diodes, 32 and 34, is a P channel FET, 38, having its source electrode connected to a junction point, 40, which is connected by a line, 42, to junction point, 35, its drain electrode connected to voltage source VM at line, 12, and its gate electrode connected to a junction point, 44. A resistor, 46, is connected between the source electrode, at junction point 40, and the gate electrode at a junction point, 44. Junction point 44 is also connected through a resistor, 48, to the collector of an NPN transistor, 50, the emitter of which is connected to signal ground. The base of transistor, 50, is connected to a junction point, 52, between a pair of resistors, 54 and 56, connected in series between a regulated DC voltage source, VCC, and signal ground. VCC is derived from a voltage regulator circuit, and turns "off" and "on" with VM.

[0013] In operation, whenever the system is driving the shaft, 28, toward the stall point and during the time the shaft is at the stall point, the power, VM, and VCC are "on." Resistor, 54, and resistor, 56, are chosen to produce a sufficient bias voltage at the base of transistor, 50, which turns it "on" creating a path from the source electrode of the FET 38 to signal ground through resistors, 46 and 48. This provides a gate signal to FET, 38, which turns it "on" and Zener diodes 32 and 34 are short-circuited with only the conventional diode 36 in the flyback current path. Since FET, 38, is not current controlled, it does not turn "off" when switch 24 is closed. It only turns "off" when VCC falls below a predetermined value. This occurs when VM, and thus VCC, are "off" and the system is de-energized and when spring, 30, pulls shaft, 28, and motor, 20, in reverse, the voltage at junction point, 52, disappears and transistor 50 turns "off". The gate of FET, 38, is no longer biased "on" thus, turning FET switch, 38, "off." In the "off" condition, Zener diodes 32 and 34 are no longer short circuited and they may now operate to control the voltage induced in motor, 20, and enhance the braking effect as they are designed to do.

[0014] It is therefore seen that we have provided a circuit for bypassing the voltage controlling devices in a flyback circuit of a DC brush motor. This is accomplished

without unnecessary power dissipation in the bypass circuit. Many changes and modifications to the preferred embodiment describe will occur to those having ordinary skill in the art. For example, the number of diodes may be changed to provide the desired operation and various drive means and bias devices may be used in place of gears 26 and spring 30. If VM is a regulated voltage source, it may replace VCC and, in some cases, it may be possible to use an unregulated source for VCC provided junction point, 50, is of sufficient voltage to turn transistor, 50, "on." We therefore do not wish to be limited to the specific structures used in connection with the description of the preferred embodiment.

Claims

1. Apparatus (10) for use with a motor (20) which is energized by a voltage source (14) to drive in a first direction and which returns in a opposite direction under the force of a bias (30) when the voltage source is removed, the motor having a voltage control device (32, 34) in the flyback path to limit the voltage induced during the return, the apparatus **characterised by** (32, 34) comprising:

a voltage controlled switch (38) connected across the voltage control device (32, 34) to short circuit the voltage device when activated; and
a sensor connected to activate the voltage-controlled switch (38) when the motor (20) is energized to drive in the first direction.

2. Apparatus (10) according to claim 1 wherein the voltage controlled switch (24) is a FET (38) that turns "conducting" to short circuit the voltage control device (32, 34) when the voltage source is "on" and which turns "non-conducting" to allow the voltage control device to control the voltage when the voltage source is "off".
3. Apparatus (10) according to claim 2 wherein the sensor includes a transistor (50) connected to the voltage source and operable to turn the FET (38) "conducting" and "non-conducting" as the voltage source turns "on" and "off".
4. Apparatus (10) according to claim 3 wherein the gate of the FET (38) is connected to the transistor (50) to cause the FET to be conducting when the transistor is "son".
5. Apparatus (10) according to claim 4 wherein the FET (38) has source and drain electrodes connected across the voltage control device (32, 34) so that, when conducting, the FET short circuits the voltage control device.

6. Apparatus (10) according to claim 1 or 5, wherein the voltage control device (32, 34) includes a Zener diode (32).

7. A method of minimizing excess power consumption, when a motor (20) is energized by a source (14) of voltage to move in a first direction, caused by a voltage limiting device (32, 34) that is needed to limit the voltage generated when the motor is moved in a reverse direction by a bias, the method **characterised by**, comprising the steps of:

placing a voltage controlled switch (38) across the voltage limiting device (32, 34) to short circuit the voltage limiting device whenever the switch is activated; and
de-activating the switch (38) whenever the source of voltage is removed allowing the motor (20) to move in the reverse direction.

8. The method of claim 7 wherein the de-activating step includes:

sensing the voltage energizing the motor (30); and
de-activating the switch (38) whenever the sensed voltage falls below a predetermined value.

9. The method of claim 8 wherein the sensing step includes:

connecting the base of a transistor (50) to the source of the voltage so that the transistor turns "on" only when the sensed voltage is above the predetermined value.

10. The method of claim 9 wherein the de-activating step further includes:

connecting the gate of an FET (38) to the transistor (50) so that it becomes "conducting" only when the transistor is "on"; and
connecting the source and drain electrodes of an FET across the voltage control device (32, 34) so that the FET shorts circuits the voltage control device when it conducts.

Patentansprüche

1. Vorrichtung (10) zur Verwendung mit einem Motor (20), der durch eine Spannungsquelle (14) erregt wird, um in einer ersten Richtung zu laufen, und die in eine entgegengesetzte Richtung unter der Wirkung einer Vorspannung (30) zurückkehrt, wenn die Spannungsquelle entfernt ist, wobei der Motor eine Spannungsregelvorrichtung (32, 34) im Rücklauf

hat, um die Spannung zu begrenzen, die während des Rücklaufs induziert ist, wobei die Vorrichtung, die durch (32, 34) **gekennzeichnet** ist, umfasst:

einen spannungsgesteuerten Schalter (38), der über der Spannungsregelvorrichtung (32, 34) angeschlossen ist, um die Spannungsvorrichtung kurzzuschließen, wenn er aktiviert ist; und einen Sensor, der zum Aktivieren des spannungsgesteuerten Schalters (38) angeschlossen ist, wenn der Motor (20) erregt ist, um in die erste Richtung zu laufen.

2. Vorrichtung (10) nach Anspruch 1, wobei der spannungsgesteuerte Schalter (24) ein FET (38) ist, der "leitend" wird, um die Spannungsregelvorrichtung (32, 34) kurzzuschließen, wenn die Spannungsquelle "ein" ist, und der "nichtleitend" wird, um der Spannungsregelvorrichtung zu ermöglichen, die Spannung zu regeln, wenn die Spannungsquelle "aus" ist.

3. Vorrichtung (10) nach Anspruch 2, wobei der Sensor einen Transistor (50) umfasst, der an die Spannungsquelle angeschlossen ist und betrieben werden kann, um den FET (38) "leitend" und "nichtleitend" zu schalten, wenn die Spannungsquelle "ein" und "aus" schaltet.

4. Vorrichtung (10) nach Anspruch 3, wobei die Gateelektrode des FET (38) mit dem Transistor (50) verbunden ist, um zu bewirken, dass der FET leitend ist, wenn der Transistor "ein" ist.

5. Vorrichtung (10) nach Anspruch 4, wobei der FET (38) Source- und Drain-Elektroden hat, die über der Spannungsregelvorrichtung (32, 34) derart verbunden sind, dass der FET, wenn leitend, die Spannungsregelvorrichtung kurzschließt.

6. Vorrichtung (10) nach Anspruch 1 oder 5, wobei die Spannungsregelvorrichtung (32, 34) eine Zener-Diode (32) aufweist.

7. Verfahren zum Minimieren eines überschüssigen Energieverbrauchs, wenn ein Motor (20) von einer Spannungsquelle (14) erregt ist, um sich in eine erste Richtung zu bewegen, bewirkt durch eine Spannungsbegrenzungsvorrichtung (32, 34), die nötig ist, um die Spannung zu begrenzen, die erzeugt ist, wenn der Motor durch eine Vorspannung in eine entgegengesetzte Richtung bewegt wird, wobei das Verfahren **dadurch gekennzeichnet ist, dass** es die folgenden Schritte umfasst:

Platzieren eines spannungsgesteuerten Schalters (38) über die Spannungsbegrenzungsvorrichtung (32, 34), um die Spannungsbegrenzungsvorrichtung kurzzuschließen, wenn der

Schalter aktiviert ist; und
Deaktivieren des Schalters (38), wenn die Spannungsquelle entfernt ist, was dem Motor (20) ermöglicht, sich in der entgegengesetzten Richtung zu bewegen.

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8. Verfahren nach Anspruch 7, wobei der Deaktivierungsschritt Folgendes umfasst:

Erfassen der Spannung, die den Motor (30) erregt; und
Deaktivieren des Schalters (38), wenn die erfasste Spannung unter einen vorgegebenen Wert fällt.

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9. Verfahren nach Anspruch 8, wobei der Erfassungsschritt Folgendes umfasst:

Verbinden der Basis eines Transistors (50) mit der Spannungsquelle, derart dass der Transistor nur dann auf "ein" schaltet, wenn die erfasste Spannung oberhalb des vorgegebenen Werts liegt.

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10. Verfahren nach Anspruch 9, wobei der Deaktivierungsschritt ferner Folgendes umfasst:

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Verbinden der Gateelektrode eines FET (38) mit dem Transistor (50) derart, dass er nur dann "leitend" wird, wenn der Transistor "ein" ist; und
Verbinden der Source- und Drain-Elektrode eines FET über der Spannungsregelvorrichtung (32, 34) derart, dass der FET die Spannungsregelvorrichtung kurzschließt, wenn er leitet.

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Revendications

1. Appareil (10) destiné à être utilisé avec un moteur (20) qui est excité par une source de tension (14) afin d'entraîner dans un premier sens et qui revient dans un sens opposé sous la force d'une charge préliminaire (30) quand la source de tension est supprimée, le moteur comportant un dispositif de commande de tension (32, 34) dans le chemin de retour afin de limiter la tension induite durant le retour, l'appareil étant **caractérisé par** (32, 34) comprenant :

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un commutateur commandé en tension (38) connecté aux bornes du dispositif de commande de tension (32, 34) afin de court-circuiter le dispositif de tension lorsqu'il est activé ; et
un capteur connecté pour activer le commutateur commandé en tension (38) quand le moteur (20) est excité pour entraîner dans le premier sens.

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2. Appareil (10) selon la revendication 1, dans lequel

le commutateur commandé en tension (24) est un TEC (38) qui devient "passant" pour court-circuiter le dispositif de commande de tension (32, 34) quand la source de tension est "active" et qui devient "bloquant" pour permettre au dispositif de commande de tension de commander la tension quand la source de tension est "inactive".

3. Appareil (10) selon la revendication 2, dans lequel le capteur comporte un transistor (50) connecté à la source de tension et exploitable pour rendre le TEC (38) "passant" et "bloquant" quand la source de tension devient "active" et "inactive".

4. Appareil (10) selon la revendication 3, dans lequel la grille du TEC (38) est connectée au transistor (50) pour rendre le TEC passant quand le transistor est "actif".

5. Appareil (10) selon la revendication 4, dans lequel le TEC (38) comporte des électrodes de source et de drain connectées aux bornes du dispositif de commande de tension (32, 34) de telle sorte que, lorsqu'il est passant, le TEC court-circuite le dispositif de commande de tension.

6. Appareil (10) selon la revendication 1 ou 5, dans lequel le dispositif de commande de tension (32, 34) comporte une diode Zener (32).

7. Procédé de minimisation d'un excès de consommation de puissance, quand un moteur (20) est excité par une source (14) de tension afin de se déplacer dans un premier sens, causé par un dispositif de limitation de tension (32, 34) qui est nécessaire pour limiter la tension générée quand le moteur est déplacé dans un sens inverse par une charge préliminaire, le procédé étant **caractérisé par le fait qu'il** comprend les étapes de :

placement d'un commutateur commandé en tension (38) aux bornes du dispositif de limitation de tension (32, 34) afin de court-circuiter le dispositif de limitation de tension chaque fois que le commutateur est activé ; et
désactivation du commutateur (38) chaque fois que la source de tension est supprimée permettant au moteur (20) de se déplacer dans le sens inverse.

8. Procédé selon la revendication 7, dans lequel l'étape de désactivation comporte :

la détection de la tension excitant le moteur (30) ; et
la désactivation du commutateur (38) chaque fois que la tension détectée chute en dessous d'une valeur prédéterminée.

9. Procédé selon la revendication 8, dans lequel l'étape de détection comporte :

la connexion de la base d'un transistor (50) à la source de la tension de telle sorte que le transistor devienne "actif" uniquement quand la tension détectée est supérieure à la valeur prédéterminée. 5

10. Procédé selon la revendication 9, dans lequel l'étape de désactivation comporte : 10

la connexion de la grille d'un TEC (38) au transistor (50) de telle sorte qu'il devienne "passant" uniquement quand le transistor est "actif" ; et 15
la connexion des électrodes de source et de drain d'un TEC aux bornes du dispositif de commande de tension (32, 34) de telle sorte que le TEC court-circuite le dispositif de commande de tension quand il conduit. 20

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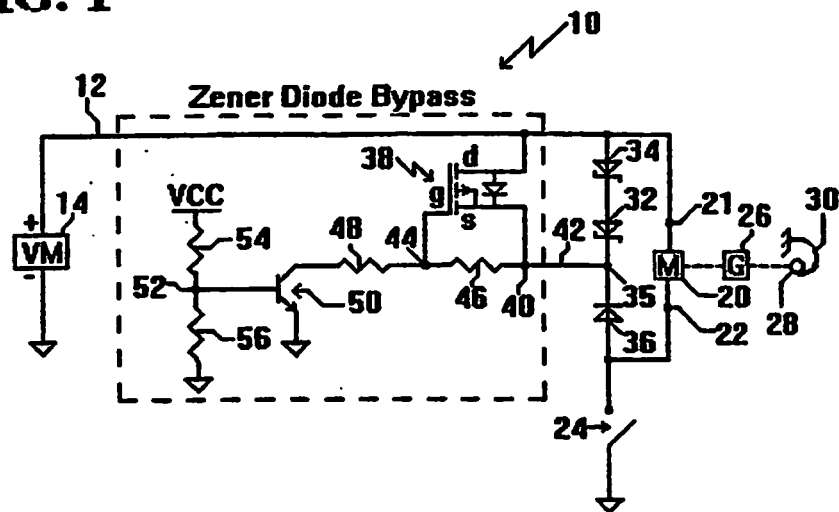
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FIG. 1



REFERENCES CITED IN THE DESCRIPTION

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